TWO OR THREE THINGS YOU NEED TO KNOW ABOUT AUI DESIGN OR DESIGNERS

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ABSTRACT

This paper presents an overview of the work on Auditory User Interface (AUI) design at the LG Electronics Corporate Design Center, where the author was responsible for all of the AUI designs from 2005 to 2008. The definition and strategy of AUI design is covered, as well as the role of AUI designers at the global company. Details on process, methodology, and design solutions of four big projects are provided. The paper also discusses how a practitioner's perspective is related to theoretical framework of auditory display. The review of this practical AUI design aims to inspire other practitioners and researchers on auditory display and sound design, and to facilitate communication in the ICAD community.

1. PRELUDE

This report introduces several aspects about Auditory User Interface (AUI) design and designers in a major electronics company and specifically aims to answer the following questions: What is AUI design and who are AUI designers? (Section 1); What type of projects do AUI designers do? What is the process of the project? How is the sound evaluation conducted? (Section 2-5); and what skills are needed for AUI design? (Section 1 and 6).

Prelude provides the definition of AUI design; and AUI designers' roles, functions, and partners at the company. This is followed by four Themes, each of which presents an overview of the big project(s) in which AUI designers can have a critical role. In each Theme, first a project concept is briefly explained. In Overall Process, meta-process of the entire project is presented. Then, in the Details and Implications, more detailed procedures, results, and related implications of the project are described. At the end of the Theme, there is a Cadenza section, which covers design considerations and suggestions. Finally, in Coda, the multi-disciplinary characteristics of AUI design are highlighted. The process delineated in this paper is relatively high level, and results are partially redacted due to company confidentiality.

1.1. Definition of AUI Design at the Company

What is AUI design? It can be defined literally by its components: "Auditory," "User," and "Interface."

Auditory. AUI designers create and manipulate auditory entities. They include non-speech sounds such as earcons [1] (e.g., function feedback sound), auditory icons [2] (e.g., analog ring sound and camera shutter sound), music (e.g., background music of visual design and the system booting), warning signals (e.g., user errors and system errors), and speech sounds (e.g., voice guidance and speech recognition).

User. AUI designers have to answer what kind of sounds users prefer and dislike, and what components of sound affect those responses. Since music and sound have a strong impact on affection or emotion [3-6], AUI designers are required to be familiar with emotion-related research as well as information aspects of sound. Therefore, they iteratively evaluate their own sound products using ample methodologies with target users.

Interface. Interface designers are required to know the specifications of the machine or the system and expected to understand system's functions and users' tasks of that particular interface. Because AUI is a type of user interface design, it includes not merely making ring tones of mobile phones, but also systematically planning and applying all of the sounds in relation to the user interface. Thus, it is different from composing artistic music by just personal inspiration.

In brief, AUI design involves the plan, analysis, creation, management, and evaluation of the product sounds. The results of AUI design should be proper for the function and image of the interface and adequate for users' needs and preference. For more academic definition of auditory display and sonification, see [7, 8].

1.2. Roles and Functions of AUI Designers

Despite its increasing importance, the position of AUI designers has not settled well with companies. AUI designers are still missionaries of AUI design itself; they have to teach and preach what AUI is and why AUI designers are needed in companies in addition to User Interface (UI) designers and Graphical User Interface (GUI) designers.

In Korean companies, AUI designers belong to User Interface Team regardless of whether it is under a design department, an engineering, or other department. Similarly, in LG Electronics, AUI designers worked with UI designers at the Corporate Design Center.

AUI designers usually work with three types of designers in the Design Center: Product designers are responsible for the overall concept of the product and outer shape; UI designers devise the user interaction, focusing on the control panel and sketching the blueprint of the overall user interface; and GUI designers are responsible for more graphical and aesthetic implementation of the UI design. AUI designers consult a product designer (and usually a hardware engineer and a representative of the product planning team) if they use any sound or voice in the product and if they can change or add speakers and amplifiers. AUI designers also identify auditory user interface logic with UI designers and decide when, where, and how the product should generate sounds. Along with GUI designers, AUI designers figure out how to conceptualize the most proper brand image and how to synchronize visual and auditory scenes.

Additionally, AUI designers mainly work with two types of engineers: hardware engineers and software engineers. With them, AUI designers discuss the specifications and location of buzzers, speakers, and amplifiers. After completing sound implementation, AUI designers have to tune the sounds in the real product because sounds are likely distorted due to software and hardware issues.

A job description for AUI design naturally includes MIDI (Musical Instrument Digital Interface) sequencing, composing and arranging music, mixing and mastering, and making sound files. They generally work with more than one partner company (i.e., sound company), but it is usually recommended for AUI designers to be able to deal with any kinds of sounds for themselves.

For analysis and evaluation of the sounds and interfaces, AUI designers need methodological frameworks. To this end, knowledge of Human Factors, Engineering Psychology, Human Computer Interaction, and some statistics can be important assets. AUI designers have to effectively report and present their work and are expected to participate in ICAD, as well as other relevant conferences such as APSCOM (Asia-Pacific Society for the Cognitive Sciences of Music) and ICMPC (International Conference on Music Perception and Cognition).

2. THEME A: AUI GUIDELINE [9]

The goal of this project was to develop a cognitive and affective AUI guideline according to product groups of household appliances so that auditory signals from the product could be intuitively mapped to their functions. This project was needed because users' mental model or expectancy has not been satisfied with arbitrarily matched sounds, which were inconsistent within and between products, and resulted in users' annoyance. Additionally, it was an attempt to overcome the GUI centered interface design and provide users with enriched multimodal user experience. The initial sound generation specification of this project was limited to a buzzer.

2.1. Overall Process

This project specifically focused on mappings between parameters of auditory signals and the functions of the products. To make these guidelines, we traced numerous considerations in creating auditory signals and extracted both general and specific guidelines. The overall process is as follows.

1) Gather general AUI guidelines
2) Analyze AUI needs based on use scenarios
3) Conduct Focus Group Interviews (FGI) and a survey on the use of AUIs in household electronic appliances
4) Conduct a Function Analysis according to product groups
5) Analyze parameters of auditory signals and create sound pools
6) Apply music rules and extract sound samples for experiments
7) Construct cognitive and affective dimensions of auditory signals
8) Develop prospective sound samples mapped to a guideline
9) Evaluate appropriateness of auditory signals and develop a final guideline

2.2. Details and Implications

In each step of the procedure, we obtained a number of basic results and specific user data. In the first step, we investigated related literature and gained general information and some guidelines on the use of sounds (limited to non-speech sounds, but beyond the specific application for household appliances), so that we could use them to improve users' understanding of the system and enhance users' performance and satisfaction. In the next step, we created some plausible scenarios about the use of various electronic devices. From those user scenarios, we identified users' mental model and particular situations that require auditory signals. Additionally, we listened to 22 household wives' notions (we call it VOC, "Voice Of Customers") about the current status of the AUIs in their household appliances using FGIs and a simple survey. They provided us with what is preferred and what is needed to improve for the auditory signals of those products. As a result of FGI, we found that household wives considered washing machines and microwaves as the most important products, which should use sounds cautiously. Meanwhile, we analyzed functions of six household electronic appliances including refrigerators, Kim-Chi refrigerators, air conditioners, washing machines, dish washers, and microwaves. A Function Analysis [10] provided us with a very useful taxonomy for application of not only AUIs but also VUIs (Voice User Interfaces). Since the application of different sounds for each of the functions might be auditory pollution, we intended to categorize the functions as meta-function groups for the application of minimal and adequate sounds. See Table 1 for the details.

We chose several attributes of sounds within the limitations of the physical specification of the buzzers used in the products. Finally, the number of notes, frequency and frequency range, melody pattern (including polarity), duration of the entire sound, and tempo of the sound were considered. Timbre, which is a critical factor in mapping data to sounds [11], was excluded because this study was limited to the use of buzzers which can generate only a single timbre. Based on expert consultation and literature analysis, 45 sounds were finally created for the experiment.

Sound parameters of these samples were mapped to the functional hierarchy within the product. It is very similar to the application of earcons for hierarchical menus (e.g., [12-15]) except that sound was mapped to functional hierarchy instead of menu hierarchy. Moreover, it included more specific guidelines for musical parameters than previous works.

To match sounds with functions, participants rated the appropriateness of every single sound with every function. The results indicated that the signals devised as the specific functions were rated high for the intended functions. This demonstrated that the rules which we applied for the sound samples were valid for users' mental model and expectancy for AUIs in the household products.

In addition to this direct mapping, we tried to match sounds with functions using affective words as a medium between them. The results were also positive. For example, the function, 'Power on' was linked with the words 'alive' and 'vivid'; and increasing sounds. 'Error' was correlated with 'embarrassed' and 'nervous'; and repetitive sound patterns.

Table 1: Functional Grouping of Household Products for AUI

Functions	Descriptions	Examples
Power on/off	Turn on/off the products	Most of the electronic products
Horizontal shift	Change the mode between the same levels	Select the type of food in the microwave
Vertical shift	Change the level up and down	Decrease temperature in the air conditioner
Function on/off	Start/pause the general functions	Start the washing machine after the option settings
Inform	Inform the end of the function /ask a user's action	Finish the washing cycle/ microwave
Warn	Warn the system's or user's errors	Door is open in the refrigerator
Special functions	Play/(pause) the special functions	Brand-specific wind in the air conditioner

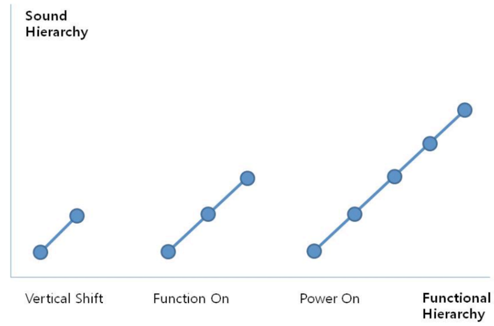

Figure 1: A conceptual figure of sound hierarchy mapped to functional hierarchy. Multiple sound attributes were differentiated due to functional hierarchy including the number of notes, duration, and the range of frequency.

To compare newer sounds with the existing sounds in the product usage context, participants evaluated two sets of sounds (new and existing) on the information architecture of the real product image using the low fidelity software-based prototypes (MS PowerPoint). The results showed that the new sounds obtained higher scores on the appropriateness, preference, and overall satisfaction scales.

Finally, professional composers created several sound sets fitting the guideline details, the brand identity of LG Electronics, and each product group image.

This project provided a meta-guideline for the AUI of LG Electronics household products. The process consisted of several aspects of interaction design such as participatory design of the target user group and user evaluation. Nonetheless, it still had several shortcomings. Since these were buzzer applications, we excluded factors such as timbre, loudness, and harmony of the sounds. Additionally, the last evaluation was conducted using low fidelity prototypes. In the next project, these points were improved to attain higher validity.

2.3. Cadenza

1) Several considerations are needed to decide frequency range: masking, buzzers' prominent frequency, less sensitivity to high frequency of old adults.
2) Buzzer-generated frequency is sometimes not same as musical frequency (e.g., 1045Hz vs. 1046.5Hz for C6). Thus, AUI designers have to tune in the real product.
3) Consider looping (repetition) of the sounds when making sound patterns.
4) In general, we use sounds shorter than 2 seconds.

3. THEME A': VUI GUIDELINE [16]

Theme A' is a variation of the Theme A. While Theme A deals with a meta-guideline for auditory user interface, Theme A' deals with a meta-guideline for voice user interface. Note that this VUI guideline includes a speech recognition part, but focuses more on voice feedback and voice guidance. Indeed, speech recognition is also a critical area that an AUI designer has to cover at an electronic company. Speech recognition is more often addressed for automotive user interface than other interfaces. We made a separate guideline for automotive user interface (e.g., [17]), but see the Volkswagen group's recent research [18] for a more accessible reference which discusses practical issues relevant to speech recognition in the vehicle. Voice feedback once disappeared from the household appliances market, but has reappeared since early 2000 (e.g., LG Electronics and Samsung Electronics) due to improvements in the quality of Text-to-Speech (TTS) and speech recognition techniques.

The use of speech is the most basic method to convey information or feedback auditorily in user interfaces. Therefore, guiding usage procedures of the product via voice user interface can enhance usability and increase product value [19, 20]. Moreover, since speech delivers more specific meaning than non-speech sounds does, it can make user interfaces more efficient and satisfactory [21]. We found some research on voice user interface, related to command vocabulary and command syntax [22] or combining human speech and TTS [23]. However, there has been little research on detailed voice feedback for overall functions of specific household electronic appliances. In this study, again, 6 groups of household products were analyzed (only the microwave was replaced by an oven range from the AUI project of Theme A).

3.1. Overall Process

The procedure was very similar to the AUI guideline project except that we devised a higher fidelity touch screen prototype of a voice user interface for each product. It is one of the most critical improvements from the AUI guideline project, which allowed for more external validity.

1) Conduct a Function Analysis of 6 products
2) Conduct a Task Analysis of respective use cycles
3) Extract usability issues (FGI)
4) Create prototypes of 6 products with VUI
5) Conduct an experiment
6) Finalize the VUI Guideline

In this study, in addition to a Function Analysis, we did a Hierarchical Task Analysis [24] to gain more detailed task procedures for each product. As a result of analysis, we divided products into two groups. Washing machines, dish washers, and oven ranges belonged to the product type that has a start and an end of the task in the product cycle. In this product category, users have to wait for the end of the system operation after their final input. For (Kim-Chi) refrigerators and air conditioners, if users manipulate the operating status, it is reflected immediately by the system. Guidelines should be different for these two types of products.

Based on design experience and Focus Group Interview results, we extracted major usability issues for voice user interface of electronic goods as follows: physical attributes of voice (e.g., gender, tone, and intonation), honorific expression according to usage context (mainly in Korean, thus excluded from this paper), simplicity of VUI (e.g., duration and in setting value guidance), and type of informing/warning. Including each issue in four sessions, we conducted an experiment with 34 house wives. We measured preference, appropriateness, task errors, and reaction time. The experiment was composed of pre-analysis and practice session, experiment, post-interview, and survey. In a practice trial, participants could get familiar with the touch screen prototype. After completing the practice trial and basic demographic questionnaire, participants entered the Usability Testing room. During the experiment, one camera recorded overall behavior of the participant and the other camera captured the touch screen. The questionnaire for each condition was composed of a seven point Likert scale.

3.2. Details and Implications

3.2.1. Physical Attributes of Voice

In voice user interfaces, physical attributes of voice could be critical factors because cognitive efficiency and affective satisfaction with the interface might be different depending on them. Participants rated female voices higher than male voices on preference and appropriateness scales. Moreover, notions of participants about male voices were negative. They noted that a male voice was unfamiliar and awkward for electronic goods. This tendency to favor female voices is consistent with previous research [23, 25].

For voice tone, we obtained unexpected results. Participants preferred the usual tone of the female voice over the high tone of the female voice. Usually, in a voice response system, a female voice of high tone is considered more vivid and kind, and thus preferred. However, in this study, people favored the common tone because they considered it as more reliable and comfortable for the electronic appliances. We might infer that since the household appliances are used every day at home, the result might be different from the case of a voice response system, which is used infrequently by the same user.

Intonation including inflection and stress is one of the most important factors for expressiveness of the speech [26] and could be implemented in various ways. In this study, it was limited to two types: dynamic and general. We found that if it was not too exaggerated, there was little difference in preference between the two types of voices.

3.2.2. Simplicity of Voice Expression

As mentioned earlier, while the use of speech is the clearest way to convey meaning aurally, it requires some time. If user's operations are repetitive, the long duration of the same voice feedback gets even worse. From this perspective, we attempted to identify the most proper speech expression in repetitive functions such as mode change or value adjustment.

We implemented and compared three types of sounds: value + predicate (e.g., in the air conditioner, "25 degree"), value-only (e.g., “25”), and directional non-speech sounds (e.g., two notes such as ‘Sol’, ‘La’ for increasing value). Participants liked the second type, value-only the most. They reported that value + predicate was too long and annoying. Non-speech sounds were reported as not distinct.

In addition to this issue, we examined one more issue related to simplicity. In some household appliances including washing machines and ovens, there are several steps in which the user has to set up values before the system’s operation. For these procedures, we can apply voice feedback after either every single setting or all of the settings. To test this, we implemented three conditions, again: voice feedback after every setting value; only final voice feedback wrapping up all setting values; non-speech sounds after every setting and final voice feedback once wrapping up all setting values. As might be expected, participants preferred the last condition, a combination of non-speech sounds and voice.

3.2.3. Informing/Warning Voice

The existing household products generated only non-speech sound signals when they required the user’s action or warned the user that there is an error. Therefore, users have to approach and check the control panel of the product. Based on FGI, the use of voice in informing/warning situations was expected to be very helpful. Accordingly, we devised three conditions for that scenario as follows: non-speech sounds only, voice only, and non-speech sounds + voice. During the experiment, while participants were watching TV, informing/warning sounds were unexpectedly generated. Then, participants had to come to the prototype and select the proper action among the options. Reaction time of non-speech sounds only was the longest, followed by non-speech sounds + voice, and voice only. However, in the appropriateness and preference scale, participants rated non-speech sounds + voice as the highest.

3.3. Cadenza

1) We used a combination of human speech for the important or repetitive parts (e.g., greetings when booting) and TTS for the less important parts (e.g., respective menu items).
2) People preferred a dubbing artist’s voice over a child’s voice for a GUI animation character (e.g., the penguin) because of the clarity of the voice and reliability of the product.
3) One of the downsides of the voice is that users have to listen to the same length-voice whenever they manipulate the same control even after they become familiar with it. To compensate for this, irrespective of dials or buttons, we apply non-speech sounds + silent interval + voice. Therefore, when users are accustomed to the interface and use the control rapidly, they hear only short non-speech sounds signal.
4) Results of the analysis with regard to age showed that older adults preferred a voice user interface more than young adults. It might be because older adults are less familiar with the electronic goods and they need more guidance of using the products. Gradual loss of vision might be one of the reasons for this.

4. THEME B: EMOTIONAL PALETTE [27]

Whereas Theme A and A' focus on the functional mapping of sound and voice, Theme B and B' focus more on the emotional (or affective) mapping of sound even though they still have functions as well.

Emotional design is becoming more and more important. However, the systematic approach to integration of emotional user experience elements in the product design has rarely been tried. The goal of the Emotional Palette project was 1) to make a common design identity (or language) in order to foster communication among designers of each design section at the company, and with outside partners and 2) to find optimized combinations of basic elements through user study and to build design guidelines for affective design elements. Designers have their own feelings and standards about design elements. To express ‘energetic’, a designer may want to choose ‘red’, but another may choose ‘black’. Even if they all want to use ‘red’, each ‘red’ might be differently imagined and expressed (Think about one of the important issues of Cognitive Science, ‘Qualia’, see e.g., [28]). This variance is good for the creativity of the work, but sometimes hinders the desirable congruency to represent corporate identity. There have been several studies about design elements and emotional factors [29-32], but none is comparable with this study in scale or methodology.

The methodology of this study mainly relied on the Kansei engineering [33], or the Sensibility Ergonomics [34], which is pervasive in academic and industrial community in Asia (but not limited to Asia, see, e.g., [35]). In this type of research, researchers usually adopt affective words as a medium between physical elements and emotion (or affection) about a certain domain.

In this study, first, we extracted affective keywords fitting corporate design directions based on design trend analysis. Then, user experience elements were created and matched with affective words. Finally, a prototype system was made to guide the design of affective factors in electronic products. In this study, user experience elements were defined as color, material & finishing, and sound.

4.1. Overall Process

1) Extract 31 affective keywords through various document analysis and trend analysis
2) Create user experience element stimuli sets (each set of color, material & finishing, and sound)
3) Measure appropriateness for participant’s self-image and for various product groups’ image, and preference depending on each of user segmentation groups.
4) Construct respective sensibility dimensions of each product group that contain mapping between keywords and design elements according to user segmentation groups.

5) Develop a prototype system based on the results of the research above.

4.2. Details and Implications

4.2.1. Extracting Trend Keywords

First, 120 affective words were extracted through trend analysis by experts group (*Nelly Rodi* in France). Additionally, we collected 342 trend adjectives by means of literature and previous research analyses, and designers' free association reports. Then, user experience designers—two color experts, two material & finishing experts, and two sound experts—extracted 50 keywords by rating the validity of collected sensibility adjectives. The standards for the validity were the degree of reflection of design trend and the appropriateness for each design element. We finally selected 31 design trend keywords eliminating simple description or technical words.

4.2.2. Designing and Matching Emotional Design Elements

Each expert group composed appropriate stimuli for the 31 affective words. Color was shown as color bars and material & finishing displayed as representative images. A few stimuli sets were chosen and elaborated by domain experts before the experiment.

For the mapping experiment between design elements and keywords, a total of 320 participants were recruited according to each of product group's market segmentation. Participants were provided with sets of design elements, and asked to answer several questions about preference and fit for self-image and for each product group. In the case of sounds, they could listen to one stimulus repeatedly. As a result of the experiment, we could obtain a mapping between each design stimulus, affective words, and user segmentation using Multi-Dimensional Scaling and Correspondent Analysis.

4.3.3. Developing Emotional Design Guideline System

Based on the results above, a prototype system was developed to guide designers to properly combine affective elements with the design concepts (see Figure 2). Above all, designers can see 31 adjectives on the 2-Dimensional coordinate system. When a designer chooses a trend keyword, the proper color bar and the material & finishing images are recommended on the right side of the system with a representative image on the bottom left. Two or three sounds that were rated highly on the concept can be heard via a sound tab. Moreover, designers can check the appropriateness of design elements according to users' segmentation. Finally, diverse combinations of all of these elements can be presented at once. It is worth noting that these elements may function as recommended samples to construct a common language between hundreds of designers for corporate design identity, but may not function as a predefined material for real products.

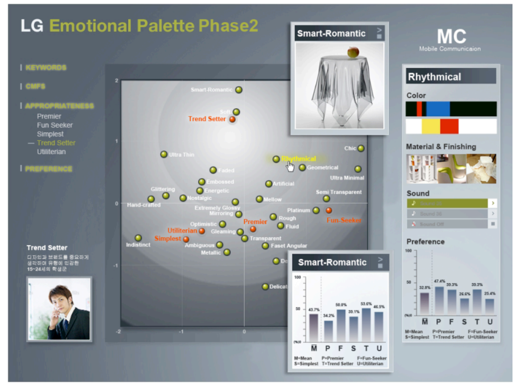

Figure 2: A screen shot of Emotional Palette prototype system for mobile phones. Design elements mapped to keywords and segmented user groups.

5. THEME B': SONIC LOGO

Even though the preceding three projects are all related to improving product identity, the most relevant project to corporate brand identity for AUI designers is creating a sonic logo, (also called sonic brand or jingle, imagine Intel's sound). For this type of project, AUI designers need to collaborate with other parts of the company beyond designers, including marketing and product-planning, etc. Among many of the sounds used in electronic products, customers and users are likely to remember the sound generated when they turn on or off the system. For example, you may be easily able to recall the Microsoft Windows' opening or closing sound. Therefore, our strategy was to create a power sound as a sonic logo and develop and apply it to other areas such as demos and advertisements on TVs, radios, and web sites. Even though users' vision is occupied with other tasks, this sound can remind them of a unique brand image. Therefore, the sonic logo should be matched with the image of the corporate identity.

5.1. Overall Process

We attempted to develop a sonic logo following general procedure, but it may vary on a case by case basis.

1) Position the image of our own company brand
2) Position the image of the existing jingles of other companies
3) Position the image of the product groups
4) Create and select sound samples
5) Develop theme variations and music

The overall process might look simple, but each step includes complex collaborations and considerable reports and decision making. This is what we consider the 'iterative design and evaluation process' itself.

5.2. Details and Implications

If the company already has a brand image positioning map, the project can be easily started. It is because brand image positioning is 1) the first step of this project; 2) the most difficult part, having to draw an agreement from each part of the company; and 3) outside the designers' job. Meanwhile, we collected and analyzed competitors' jingle sounds. Analyses include the number of notes, duration, key, rhythm, type of timbre, use of voice, chord progression, type of coda, usage scenes, and overall impression. Results of analyses helped us make our sound distinct from others while keeping it comparable to others in quality.

One of the easiest ways to differentiate feelings between product groups is to apply a different timbre for each sound (this is impossible for the buzzer system, though). For example, we might create one simple melody contour for all the household appliances and vary it with different timbres: Woodwinds for air conditioners; bell sounds for refrigerators; and water drop sounds for washing machines.

System booting sounds are a type of sonic logos. When designing the system booting sound, various collaborations with other designers occur. For the case of one of the premium TVs, product designers requested a specific scenario of 'power on' for the TV (like the sun rise from the Milki-Way). Thus, we created several samples of corresponding sound for that scene. In another case of a blue-ray player, GUI scenes such as the beginning of the movie were first conceptualized and were followed by AUI alternatives. One interesting case was the design of the booting sound of a Personal Navigation Device (PND). In our PND models, there was no booting sound. However, in that specific model, the system booting lasted too long due to a hardware issue. In a development meeting, we came up with an idea of using sound to compensate for this boring time. This can be a good example of an application of Cognitive Psychology to AUI design. According to the Cognitive-Attention Theory, doing a concurrent task while monitoring time passage leads to temporal estimates that are shorter than without the task [36]. We expected that adding sounds might make users humming and be less annoyed while waiting for the system to boot up. Consequently, in this particular model, AUI was created first and was followed by appropriate GUI designs.

5.3. Cadenza

1) Most of the companies uses major keys, but some (e.g., 'National' in Japan) uses minor keys in their jingle.
2) Sonic logos can be made without melody contours (e.g., Macintosh), but in this case, it is generally difficult to apply the sound to a buzzer system.

6. CODA

This paper presented a short review of AUI design at an electronic company. Since Pythagoras and Plato, there have been attempts to create the corresponding relations between the physical phenomena of sound and psychological responses to them. Along the same line, a semiotic approach to today's sound design [37] looks valid because it is the science of mapping auditory signal to meaning (e.g., function, hierarchy, image, and emotion). Even though music or sound is very subjective and depending on emotional state, to be more scientific we have adopted language (e.g., functional words and adjective words) as a logical linkage between sound and mind because most people have expertise in their language and use it as an effective communication tool in everyday lives.

The methods and processes used in this paper are not all we have used and may not be ideal. Notably, the guidelines presented here are for specific electronic products of the particular company. Moreover, guidelines sometimes do not work well when we design for a real, specific product because there are always unexpected issues. Therefore, they may not function for other products or in other contexts. Indeed, the ICAD community has not developed the standard sounds, methods, tools, and evaluation techniques with respect to auditory user interface design yet. This type of case study might contribute to laying a brick for that foundation.

Auditory display is an interdisciplinary science. The author has studied sociology, cognitive science, engineering psychology, and film scoring. Other areas that current AUI designers majored in include computer science, classical music, computer music, and user interface design. However, irrespective of majors, whoever likes or is interested in music (auditory), mind (user), and machine (interface) can tackle the challenge.

7. ACKNOWLEDGEMENT

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8. REFERENCES

[1] M. M. Blattner, D. A. Sumikawa, and R. M. Greenberg, "Earcons and icons: Their structure and common design principles," *Human-Computer Interaction,* vol. 4, pp. 11-44, 1989.

[2] W. W. Gaver, "Auditory icons: Using sound in computer interfaces," *Human-Computer Interaction,* vol. vol.2, pp. 167-177, 1986.

[3] P. Kenealy, "Validation of a music mood induction procedure: Some preliminary findings," *Cognition and Emotion,* vol. 2, pp. 41-48, 1988.

[4] J. D. Mayer, J. P. Allen, and K. Beauregard, "Mood inductions for four specific moods: A procedure employing guided imagery vignettes with music," *Journal of Mental Imagery,* vol. 19, pp. 133-150, 1995.

[5] J. Panksepp, and G. Bernatzky, "Emotional sounds and the brain: The neuro-affective foundations of musical appreciation," *Behavioural Processes,* vol. 60, pp. 133-155, 2002.

[6] V. N. Stratton, and A. H. Zalanowski, "The

effects of music and cognition on mood," *Psychology of Music,* vol. 19, pp. 121-127, 1991.

[7] B. N. Walker, and G. Kramer, "Auditory displays, alarms, and auditory interfaces," in W. Karwowski (Ed.), *International Encyclopedia of Ergonomics and Human Factors,* (2nd ed.) (pp. 1021-1025). New York: CRC Press, 2006.

[8] T. Hermann, "Taxonomy and definitions for sonification and auditory display," in 14th Internatinal Conference on Auditory Display (ICAD2008), Paris, France, 2008.

[9] J. Lee, M. Jeon, and K. Han, "Developing the design guideline of auditory user interface of digital appliances," *Korean Journal of the Science of Emotion & Sensibility,* vol. 10, no. 3, pp. 307-320, 2007.

[10] C. D. Wickens, S. E. Gordon, and Y. Liu, *An introduction to human factors engineering*, New York: Addision Wesley Longman, 1998.

[11] B. N. Walker, and G. Kramer, "Ecological psychoacoustics and auditory displays: Hearing, grouping, and meaning making," *Ecological psychoacoustics*, J. Neuhoff, ed., New York: Academic Press, 2004.

[12] S. A. Brewster, P. C. Wright, and A. D. N. Edwards, "A detailed investigation into the effectiveness of earcons," in the 1st International Conference on Auditory Display, Santa Fe, USA, 1992, pp. 471-478.

[13] S. A. Brewster, V. P. Raty, and A. Kortekangas, "Earcons as a method of providing navigational cues in a menu hierarchy," in *HCI'96*, 1996, pp. 167-183.

[14] S. A. Brewster, "Using Non-speech sounds to provide navigation cues," *ACM Transactions on Computer-Human Interaction,* vol. 5, no. 3, pp. 224-259, 1998.

[15] G. Leplatre, and S. A. Brewster, "Designing non-speech sounds to support navigation in mobile phone menus," in the 6th International Conference on Auditory Display, Atlanta, GA, 2000, pp. 190-199.

[16] H. Chae, J. Hong, M. Jeon *et al.*, "A study on voice user interface for domestic appliance," *Korean Journal of the Science of Emotion & Sensibility,* vol. 10, no. 1, pp. 55-68, 2007.

[17] S. Kim, J. Choe, E. Jung, S. *et al.*, "A study on the navigation menu structure with size screen," in the Korean Conference on Human Computer Interaction, Kangwon, Korea, 2008, pp. 380-385.

[18] J. Chang, A. Lien, B. Lathrop *et al.*, "Usability evaluation of a Volkswagen group in-vehicle speech system," in the 1st International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI 2009), Essesn, Germany, 2009, pp. 137-143.

[19] R. M. Mcleod, "Human factors issues in speech recognition," *Contemporary Erogonomics*, E. J. Lovesey, ed., London: Taylor and Francis, 1994.

[20] H. C. Michael, P. G. James, and B. Jennifer, *Voice user interface design*, Boston: Addison-Wesley, 2004.

[21] C. Nass, and L. Gong, "Speech interfaces from an evolutionary perspective," *Communications of the ACM,* vol. 43, no. 9, pp. 36-43, 2000.

[22] D. Johnes, K. Hapeshi, and C. Frankish, "Design guidelines for speech recognition interfaces," *Applied Ergonomics,* vol. 20, no. 1, pp. 47-52, 1989.

[23] L. Gong, and J. Lai, "Shall we mix synthetic speech and human speech? Impact on users' performance, perception, and attitude," in the SIGCHI Conference on Human Factors in Computing Systems, Seattle, WA, USA, 2001.

[24] E. Hollnagel, "Task analysis: Why, what, and how," *Handbook of human factors and ergonomics*, G. Salvendy, ed., New Jersey: John Wiley & Sons, Inc, 2006.

[25] M. K. Margulies, "Male-female differences in speaker intelligibility: Normal versus hearing impaired listeners," *Journal of Acoustical Society of America,* vol. 65, no. S1, pp. S99-S99, 1979.

[26] T. V. Raman, *Auditory user interfaces: Toward the speaking computer*, Boston: Kluwer Academic Publishers, 1997.

[27] M. Jeon, U. Heo, J. Ahn *et al.*, "Emotional Palette: Affective user eXperience elements for product design accoring to user segmentation," in the International Conference on Cognitive Science, Seoul, Korea, 2008.

[28] G. Harman, "Some philosophical issues in Cognitive Science: Qualia, intentionality, and the mind-body problem," *Foundations of Cognitive Science*, M. I. Posner, ed., pp. 831-848, Boston: MIT Press, 1998.

[29] L. M. Brown, and J. J. Kaye, "Eggs-ploring the influence of material properties on haptic experience," in the 2nd International Workshop on Haptic and Audio Interaction Design, Seoul, Korea, 2007, pp. 1-2.

[30] J. Lee, M. Jeon, Y. Kim *et al.*, "The analysis of sound attributes on sensibility dimensions," in the 18th International Congress on Acoustics, Kyoto, Japan, 2004, pp. 1795-1798.

[31] D. Payling, S. Mills, and T. Howle, "Hue music-creating timbral soundscapes from coloured pictures," in the International Conference on Auditory Display, Quebec, Canada, 2007, pp. 91-97.

[32] R. Bresin, "What is the color of that music performance," in the International Computer Music Conference (ICMC2005), Barcelona, 2005, pp. 367-370.

[33] M. Nagamachi, "Kansei Engineering as a powerful consumer-oriented technology for product development," *Applied Ergonomics,* vol. 33, pp. 289-294, 2002.

[34] K. Lee, "Sensibility Ergonomics: Needs, concepts, methods, and applications," *Korean Journal of Ergonomics,* vol. 17, no. 1, pp. 91-102, 1998.

[35] J. A. Kleiss, "Characterizing and differentiating the semantic qualities of auditory tones for products," in the Human Factors and Ergonomics Society 52nd Annual Meeting, 2008, pp. 1692-1696.

[36] N. S. Hemmes, B. L. Brown, and C. N. Kladopoulos, "Time perception with and without a concurrent nontemporal task," *Attention, Perception, & Psychophysics,* vol. 66, pp. 328-341, 2004.

[37] A. Pirhonen, K. Tuuri, M. Mustonen *et al.*, "Beyond clicks and beeps: In pursuit of an effective sound design methodology," *HAID 2007, LNCS 4813*, I. Oakley and S. A. Brewster, eds., pp. 133-144, 2007